CONTENTS

Dedi	cation	iii	1.26	Future Developments in the ASME B & PV Code	1-25
Ackn	owledgements	v		Summary References	1-36 1-36
Cont	ributor Biographies	vii	1.20	11010101000	1 00
Prefa	ice	xxxi	CHAI	PTER 2 The Maintenance Rule	
			C. W	esley Rowley	2 -
Intro	duction	. xxxv			2-1
			2.1 2.2	Introduction	2-1 2-1
OLI A	DTED 4 . History of the Oads Dules for		2.2	Purpose and Scope Responsibility	2-1 2-2
	PTER 1 History of the Code Rules for		2.3 2.4	Applicability	2-2 2-2
	editation, Certification, and Related Issues		2.5	Terms and Definitions	2-2 2-2
Richa	ard Stevenson and Marcus N. Bressler	1-1	2.6	General Requirements	2-4
1.1	Introduction	1-1	2.0 2.7	Use of Existing Standards and Programs	2-4
1.2	Historical Background	1-1	2.8	Methodology of Selecting Plant Structures,	2
1.3	Nuclear Energy	1-2	2.0	Systems, and Components	2-4
1.4	Piping, Vessels, Pumps, and Valves in	. –	2.9	Establishing Risk and Performance Criteria	2
	the 1950s	1-2	2.5	(Goal Setting) and Monitoring	2-5
1.5	ASME Section III, Nuclear Vessels, in	. –	2 10	SSCS Subject to Effective Program	2-0
	the 1960s	1-3	2.10	Maintenance Programs	2-9
1.6	Piping, Pumps, and Valves in the 1960s	1-3	2 11	Evaluation of Systems to Be Removed from	2.0
1.7	Certification for Nuclear Construction	1-3	2.11	Service	2-10
1.8	Developments of the 1970s	1-4	2 12	Periodic Maintenance Effectiveness	2-10
1.9	The Registered Professional Engineer	1-5	2.12	Assessments	2-12
1.10	Authorized Inspection	1-5	2 13	Documentation	2-13
1.11	Quality Assurance	1-6		References	2-13
1.12	Inservice Inspection	1-7		Tioloromodo	
1.13	Construction Code-Section XI Interfaces	1-7			
1.14	Repairs and Replacements	1-7	СНАІ	PTER 3 Pipe Vibration Testing and Analysi	•
1.15	•			E. Olson	
	Operating Plants	1-8	David	1 E. OISON	3-
1.16	Careful Preparation of Work Plans	1-8	3.1	Piping Vibration Characteristics	3-1
	Code Reconciliation	1-8	3.2	Vibration Experience with U.S. Nuclear	
1.18	Example A: Repair of Steam-Generator			Power Plants	3-1
	Feedwater-Nozzle Cracks at a Nuclear Plant		3.3	Allowable Piping Response for Vibration	3-2
	in the 1970s	1-8	3.4	Review of ASME/ANSI O&M Standard on	
1.19	Example B: ENP-Support Material			Piping Vibration	3-4
	Requirements	1-10	3.5	Causes of Piping Vibration	3-5
1.20	Materials Procurement	1-13	3.6	Design Considerations and Guidelines	
1.21	Materials Documentation	1-14		for Piping	3-12
	Component Procurement for Replacements	1-14	3.7	Vibration Testing and Analysis	3-16
1.23	Use of Specific Provisions of Later		3.8	Future Development of the OM-3 Piping	
	Editions and Addenda	1-14		Vibration Standard	3-35
	Nuclear Certification Programs	1-14	3.9	Acknowledgments	3-36
	Globalization	1-19	3.10	References	3-36

	PIER 4 Stress Intensification Factors,		6.5	Earthquake Loads	6-8
Stres	s Indices, and Flexibility Factors		6.6	Vibratory Loads	6-13
Antho	ony W. Paulin, Jr. and Everett C. Rodabaugh	4-1	6.7	Relief-Valve Discharge Load	6-14
4.4	latus divetta a	4 4	6.8	Fluidhammer	6-14
4.1	Introduction	4-1	6.9	Multi-Phase Flow Analysis with CFD	6-15
4.2	Terminology and Symbols	4-1		Pipe Break	6-17
4.3	Stress Intensification Factors	4-2	6.11		6-17
4.4	C and K Stress Indices	4-6	6.12	Missiles	6-17
4.5	Fatigue Evaluations: Class 2 or 3 Piping and		6.13	References	6-19
	Class 1 Piping	4-11			
4.6	B-Stress Indices	4-12			
4.7	Piping System Analyses and Flexibility		CHAI	PTER 7 Operability and Functionality	
	Factors	4-13		ification	
4.8	Examples	4-14			7.
4.9	ASME B31.1 [36] and B31.3 [37] Piping		Stept	nen R. Gosselin and Thomas C. Esselman	/-
	Codes	4-18	7.1	Introduction	7-1
4.10	ASME B31.1: Power Piping [36]	4-18	7.2	Mechanical Components and Failure Modes	7-3
	ASME B31.3: Power Piping [37]	4-18	7.3	Operability/Functionality Evaluations	7-7
	References	4-19	7.4	ASME Code Requirements	7-9
			7.5	Operability Evaluation Methods	7-12
			7.6	Short-Term Operability Acceptance Criteria	7-12
CHA	PTER 5 Code Design and Evaluation for		7.7	Long-Term Operability	7-16
Cycli	c Loading-Sections III and VIII			Probabilistic Assessment of Operability	
-	m J. O'Donnell	5-1	7.8		7-16
vviiia	III 0. 0 Doillicii	J-1	7.9	Common Term Definitions	7-16
5.1	Background	5-1		Nomenclature	7-17
5.2	Use of Strain-Controlled Fatigue Data	5-1		Acknowledgement	7-17
5.3	Stress/Strain Concentration Effects	5-2	7.12	References	7-18
5.4	Effect of Mean Stress	5-2			
5.5	Fatigue Failure Data	5-4			
5.6	Procedure for Fatigue Evaluation	5-6	CHAI	PTER 8 Fluids	
5.7	Cumulative Damage	5-6	Frede	erick J. Moody	8-
5.8	Exemption from Fatigue Analysis	5-6			
5.9	Experimental Verification of Design Fatigue		8.1	Introduction	8-1
0.0	Curves	5-7	8.2	The Nature of Fluid Forces	8-1
5.10	Use of Mean Stress Corrections and Cyclic	0.	8.3	Disturbance Sources	8-3
0.10	Stress-Strain Properties	5-8	8.4	Estimating Fluid-Flow Forces in Pipes	8-10
5 11	Current Code Determinations for New	0 0	8.5	Fluid Forces on Submerged Structures	8-10
3.11	Fatigue Design Life Evaluation Curves	5-9	8.6	Fluid—Structure Interaction	8-11
E 10		5-9	8.7	Vessel Steam Pipe Rupture Force on	
5.12	Proposed New Fatigue Design Curves for			Vessel Internals	8-15
	Austenitic Stainless Steels, Alloy 600 and	- 44	8.8	Shock Reflection at the Interface of a	
- 40	Alloy 800 in Air	5-11		Bubbly Liquid	8-22
5.13	Developments in Environmental Fatigue		8.9	Summary	8-27
	Design Curves for Carbon and Low Alloy			References	8-28
	Steels in High Temperature Water	5-11			· - ·
5.14	Developments in Environmental Fatigue				
	Design Curves for Austenitic Stainless Steels	5-21	CHAI	PTER 9 Bolted-Flange Joints and	
5.15	Environmental Fatigue Temperature			nections	
	Corrections	5-22			_
5.16	Current Regulatory Status	5-24	Willia	m J. Koves	9-
5.17	Key Literature	5-24	9.1	Introduction	9-1
5.18	References	5-24	9.1	Codes Addressing Flange Design	9-1
			9.3		9-1
	TED 0 D 6		9.3 9.4	Flange Design for Pressure Vessels	9-5
CHAPTER 6 Perspective on Cyclic, Impact, and				Flange Design for Piping	
Impu	lse Loads		9.5	Flange Standards	9-7
Micha	ael A. Porter	6-1	9.6	Flange-Design Methods	9-7
			9.7	Design for External Loads	9-31
6.1	Introduction	6-1	9.8	Tightness-Based Design	9-32
6.2	Types of Dynamic Loads	6-2	9.9	Flange-Joint Assembly	9-34
6.3	Glossary	6-3		Future Code Requirements	9-36
6.4	Basic Equations of Motion and		9.11		9-36
	Time-Dependent Loading Functions	6-6	9.12	References	9-36

Trans	TER 10 The Evolution of U.S. portation Regulations for Radioactive		12.3 12.4	Managing Risk Applied D&D Engineering Management	12-4 12-4
	als — An Updated Retrospective	10.1	12.5 12.6	Technology Development Needs Conclusions	12-4 12-7
nonaid	. Э. панен	10-1	12.7	References	12-7
10.1	Introduction	10-1			
10.2	Background	10-1			
10.3	Title 10, Code of Federal Regulations,		CHAP	TER 13	Omitted
	Part 71 (10 CFR 71)	10-2			
10.4	Major Changes — 1968	10-6			
10.5	Transfer of Licensing Responsibilities from			TER 14 Seismic Protection for	
	DOT to AEC	10-9	Press	ure Piping Systems	
10.6	Double Containment for Plutonium, and		Chakı	apani Basavaraju and Mohinder L. Nayyar	14-1
	Quality Assurance Requirements —		444	Introduction	444
	1973 to 1978	10-11	14.1	Introduction	14-1
10.7	NRC Regulatory Guide 7.6	10-13	14.2	Seismic Hazard	14-1
10.8	1979 Proposed Rule, 10 CFR 71	10-14	14.3	Seismic Analysis of Piping Systems	14-2
10.9	NUREG/CR-1815, 1981	10-14	14.4	Seismic Anchor Motion (Sam) Analysis	14-6
10.10	1983 Final Rule, 10 CFR 71	10-14	14.5	Seismic II/I Piping System Protection	14-6
10.11	Additional Regulatory Guidance,		14.6	Seismic/Non-Seismic Interface	14-6
	NRC, 1985	10-14	14.7	References	14-6
10.12					
	Proposed Rule	10-15	CHAR	TED 15 Concretion III : DWDs	
10 13	Reg. Guides 7.11 and 7.12, 1991	10-16		TER 15 Generation III + PWRs	
	10 CFR 71, 1995 Final Rule	10-16		th Schwab, Marty Parece and	
	Double Containment Issues Revisited	10-10	Masai	nori Onozuka	15-1
			15 1	Introduction	15-1
	10 CFR 71, 2002 Proposed Rule	10-17 10-18	15.1		_
	10 CFR 71, 2004 Final Rule		15.2	Scope of Commentary	15-1
	Conclusions	10-23	15A	AP1000 [®] PWR	15-2
10.19 10.20	Acknowledgements References	10-23 10-24	15B 15C	EPR US-APWR	15-12 15-22
	TER 11 Pipeline Integrity and Security furray	11-1		TER 16 New Generation of BWRs yal S. Mehta	16-1
11.1	Introduction	11-1	16.1	Introduction	16-1
11.2	Cost Effectiveness and Importance of		16.2	Evolution of BWR Product Line from	
	Pipeline Transportation	11-2		BWR/1 Through ESBWR	16-1
11.3	Brief Overview of Pipeline Systems	11-2	16.3	Key Features of ESBWR	16-9
11.4	Pipeline Systems—Safety and		16.4	Materials, Fabrication, and Applicable	
	Environmental Protection	11-3		ASME Code Edition	16-16
11.5	Pipeline Integrity Management Programs	11-6	16.5	Future Direction – Fabrication and	10 10
11.6	Elements of an Integrity Management	11.0	10.0	Modularization	16-20
	Program	11-8	16.6	Summary	16-20
11.7	Risk Assessment and Risk Mitigation	11-12	16.7	References	16-20
11.8	Integrity Assessment Methods	11-16	10.7	Helefelices	10-20
11.9	Defect Assessment Methods	11-26			
11.10	Pipeline Repair	11-34	CHAP	TER 17 Future Code Needs for Very	
11.11	Pipeline Corrosion Control	11-34	High '	Temperature Generation IV Reactors	
11.12	Pipeline Protection—Coatings, Cathodic	11-39	_	m J. O'Donnell and Donald S. Griffin	17-1
11.12	Protection, Inhibition	11-41	vviiiai	11 o. O Donnen and Donald O. Gillin	
11 12		11-41	17.1	Background	17-1
11.13	Third Party Damage Awareness	11 40	17.2	Summary	17-1
44 4 4	and Control	11-48	17.3	Structural Integrity Evaluation Approach	17-3
11.14	, ,	11-52	17.4	Structural Integrity Evaluation Methods	17-3
11.15	References	11-55	17.5	Regulatory Issues	17-4
			17.6	Current Regulatory Issues for Structural	
СНАР	TER 12 Decommissioning Technology		-	Design of VHTR and GEN IV Systems	17-7
	ppment		17.7	How Structural Integrity Issues Are	
	•	40.4		Addressed by Current ASME Code?	
maroid	E. Adkins and Anibal L. Taboas	12-1		Including Code Cases and Section III,	
12.1	Introduction	12-1		Subsection NH, "Class 1 Components in	
12.2	National Efforts	12-1		Elevated Temperature Service"	17-11

17.8	Material Models Design Criteria and		21.5	Inspection Methods and Requirements	21-10
	Analysis Methods Needed in the ASME		21.6	Safety Considerations	21-13
	Code for Very High-Temperature Service	17-12	21.7	Degradation Predictions	21-15
17.9	Recent Material Data Compilations	17-13	21.8	Repairs	21-20
17.10	Perspective on Next Generation Nuclear		21.9	Remedial Measures	21-24
	Plants	17-13	21.10	Strategic Planning	21-26
17.11	References	17-13	21.11	References	21-27
	TER 18 License Renewal and Aging		CHAP'	TER 22 PRA and Risk-Informed	
_	, 10	18-1	-	S. Hill III	22-1
			22.1	Introduction	22-1
18.1	Introduction	18-1	22.1	Background	22-1
18.2	Historical Background	18-1		ASME PRA Standard ASME/	22-1
18.3	License Renewal Review Process	18-2	22.3		00.0
18.4	LRA	18-4	00.4	ANS RA-Sb-2013	22-2
18.5	Interim Staff Guidance (ISG) Process	18-8	22.4	ASME B&PV Section XI In-Service Inspection	1 22-6
18.6	Guidance Documents	18-8	22.5	ASME B&PV Section XI Repair and	
18.7	International Activities	18-10		Replacement	22-11
18.8	Disclaimer and Acknowledgement	18-10	22.6	ASME Operation and Maintenance Code	22-15
18.9	References	18-10	22.7	Regulatory and Industry Interactions	22-19
			22.8	Future Plans for Risk-Informed Activities	22-20
CHAD:	TED 10 DWD Decetor Internals and		22.9	Summary and Conclusions	22-23
_	TER 19 BWR Reactor Internals and BWR Issues		22.10	References	22-23
	val S. Mehta	10.1			
пагиа	/ai 5. Merita	19-1	CHAP.	TER 23 Standardization of Valves,	
19.1	Introduction	19-1	Flange	es, Fittings and Gaskets	
19.2	BWR Internals	19-1	(ASME	B16 Standard)	
19.3	BWR Pressure Vessel	19-6	lamps	Philip Ellenberger	23-1
19.4	Reactor Pressure Boundary Piping	19-16	barries	Trimp Encliberger	20 1
19.5	Crack Initiation, Growth Relationships,		23.1	B16: Overview of the B16 Committee	23-1
	and Plant Monitoring	19-20	23.2	Organization of B16	23-2
19.6	Summary	19-25	23.3	Generic Table Contents	23-3
19.7	References	19-25	23.4	Subcommittee B: Threaded Fittings (Except Steel), Flanges and Flanged	
0114 D	TED 00 DWD D			Fittings	23-4
	TER 20 PWR Reactor Vessel Integrity		23.5	Subcommittee C: Steel Flanges and	
and In	ternals Aging Management			Flanged Fittings	23-5
	val Mehta, William L. Server and	00.4	23.6	Subcommittee F: Steel Threaded and	00.0
TIMOUT	y J. Griesbach	20-1	00.7	Welding Fittings	23-6
20.1	Introduction	20-1	23.7	Subcommittee G: Gaskets for Flanged	00.7
20.2	Codes and Regulations for the Prevention		00.0	Joints	23-7
	of Brittle Fracture	20-2	23.8	Subcommittee J: Copper and Copper	
20.3	Reference Toughness Curves	20-8		Alloy Flanges, Flanged Fittings and	00.7
20.4	Margin Studies for Operating P-T Limits	20-13	00.0	Solder Joint Fittings	23-7
20.5	Areas for Future Improvements to		23.9	Subcommittee L: Gas Shutoffs and Valves	23-8
	Section XI, Appendix G	20-14	23.10	Subcommittee N: Steel Valves and Face	
20.6	Aging Management of PWR Vessel Internals	20-15		to Face and End to End Dimensions of	00.0
20.7	Cracking at Nozzle Penetrations and			Valves	23-8
	Dissimilar Metal Welds	20-18	23.11	References	23-9
20.8	References	20-20			
•			CHVD.	TER 24	
СНФЬ.	TER 21 PWR Reactor Vessel Alloy 600		CHAP	I LII 27	
Issues				PART A: LESSONS LEARNED BASED ON	
	A. White	21-1		SECTION VIII, DIVISION 1	
			James	C. Sowinski	24-1
21.1	Introduction	21-1			
21.2	Alloy 600 Applications	21-1		Abstract	24-1
21.3	PWSCC	21-5		Introduction	24-1
21.4	Operating Experience	21-6	24A.3	Document Size	24-2

	Writing Style and Organization	24-2		Nonmetallic Components	26-7
	Technical Issues	24-3	26B.5	Joining of Nonmetallic Components	
	Technical Background of Code Rules	24-9		(and Subcomponents)	26-8
24A.7	Common Rules	24-9	26B.6	Application Problems	26-10
24A.8	Examples Problems	24-9		Quality Assurance (QA)	26-11
24A.9	Summary	24-10	26B.8	Sensitive Aspects of Nonmetallic	
24A.10	References	24-10		Fabrication Processes	26-11
			26B.9	Conclusions	26-11
	PART B: LESSONS LEARNED BASED ON				
	SECTION VIII, DIVISION 2		CHAP	TER 27 ASME Section XI Developments	
David .	A. Osage	24-11		luation Procedures for Nuclear Piping	
				ded by Flaws and Corrosion Processes in	
	Abstract	24-11		nse to Lessons Learned	
	Introduction	24-11		as A. Scarth	27-1
	Development Objectives	24-11	Dougle	as A. Ocariir	
	Development Process	24-11	27.0	Outline	27-1
	Organization of New Code	24-11	27.1	Introduction	27-1
	Additional Development Steps	24-13	27.2	Overview of ASME Section XI for	
	Use of VIII-2 in New Construction	24-14		Evaluation of Planar Flaws	27-2
	Common Rules	24-14	27.3	Stress Corrosion Cracking in Nuclear	
	Document Format	24-20		Piping Items	27-4
24B.10	ASME Section VIII — Division 2 Criteria	04.04	27.4	Revisions to Flaw Acceptance Standards	27-4
	and Commentary	24-21	27.5	Revised Acceptance Criteria for Flaws in	
	Example Problems	24-21		Piping to Maintain Design Intent Margins	27-6
	2 Summary	24-21	27.6	Recent Developments to Address Stress	
24B.13	3 References	24-21		Corrosion Cracking in Piping Items	27-11
			27.7	Transition Temperatures for Onset of	
CHAP	TER 25 Lessons Learned Based on			Upper Shelf Behavior in Ferritic Piping	27-13
	ting Experience, Section XI		27.8	Evaluation Procedures and Acceptance	
-	Park	25 1		3 1 3	27-14
загу г	ark	25-1	27.9	Evaluation Procedures and Acceptance	
25.1	Background	25-1		Criteria for Temporary Acceptance of	
25.2	The Lessons	25-1		Flaws in Moderate Energy Classes 2 and	
25.3	References	25-5			27-15
				Evaluation of Flaws in Buried Metallic Pipe	27-15
JUVD.	TER 26		27.11		27-19
	ILIT 20		27.12	References	27-19
	PART A: LESSONS LEARNED:				
	INDUSTRY EXPERIENCE OF MATERIALS			TER 28 Lessons Learned in the Use of	
John F	. Grubb	26-1		ure Relief Devices	
06 4 4	Introduction	06.1	Chip H	l. Eskridge and Joseph F. Ball	. 28-1
	Introduction Extrapolation is Perilous	26-1 26-1	28.1	Introduction	28-1
	The Environment is Always Worse than	20-1	28.2	Terminology	28-1
20A.3	Predicted	26-3	28.3	History of Pressure Relief Devices	28-2
26 / /	Post-Fabrication Cleanup is More	20-3	28.4	ASME Codes and Jurisdictional Requirements	28-5
20A. T	Important than Generally is Believed	26-3	28.5	American Petroleum Institute Pressure	
26 / 5	Physical Properties are Important	26-3		Relief Standards	28-9
	Is the Mission of the B&PV Code Evolving?	26-4	28.6	Summary	28-11
	Acknowledgment	26-4	28.7	Acknowledgments	28-12
	References	26-4	28.8	References	28-12
20A.0	rielerences	20-4			
ΡΔΕ	RT B: LESSONS LEARNED: EXPERIENCE V	WITH	СНАР	TER 29 Insights from Nuclear Utility	
				ence with PRA Applications	
	ONMETALLIC MATERIALS IN STRUCTURA				
	PRESSURE BOUNDARY APPLICATIONS		Deepa	k Rao	. 29-1
C. Wes		26-5	•		
	PRESSURE BOUNDARY APPLICATIONS Sley Rowley		29.1	Summary and Background	29-1
26B.1	PRESSURE BOUNDARY APPLICATIONS	26-5 26-5 26-5	•		29-1

29.4 29.5 29.6 29.7 29.8 29.9	Significant PRA Applications Summary of Insights from Utility Applications Summary Acronyms Note References	29-4 29-6 29-7 29-8 29-9 29-9	 32A.5 Test Programs 32A.6 Capturing the Economies of Small 32A.7 Ready for Market 32A.8 Summary 32A.9 References 	32-8 32-10 32-12 32-12 32-12
CHAD.	FED 20 Leggans Leggans NDC Experience	_	PART B: NEW DELIBERATIONS IN NUCLEAR MODULAR CONSTRUCTION—	
	TER 30 Lessons Learned: NRC Experience apani Basavaraju		WESTINGHOUSE SMALL	
			MODULAR REACTOR	
30.1 30.2	Introduction Fukushima Lessons Learned	30-1 30-1	Alexander W. Harkness	. 32-13
30.2	Effect of LWR Environment on Fatigue	30-1	32B.1 Introduction	32-13
00.0	Life of Nuclear Plant Components	30-7	32B.2 Plant Design	32-14
30.4	Buried Pipe-Leakage Issues	30-11	32B.3 Safety	32-19
30.5	HDPE for Replacement of Carbon Steel		32B.4 Modularization and Construction	32-20
	Piping in Safety Related Class 3 Buried		32B.5 Operation and Maintenance 32B.6 Construction Code	32-20 32-21
20.6	Piping	30-11	32B.7 Licensing	32-21
30.6	Lessons Learned – BWR Steam Dryers for EPU Operation	30-15	32B.8 References	32-21
30.7	RPV Indications in DOEL & Tihange NPP	30-19		
30.8	Steam Generator Tube Leaks	30-19	CHAPTER 33 New Deliberations-Fusion	
30.9	Issues for New Construction	30-20	Reactors	
	FER 31 Power and Process Piping ns Learned		PART A: THEORETICAL BASES AND SCIENTIFIC FOUNDATIONS	
Jimmy	E. Meyer	31-1	James A. Mahaffey	33-1
31.1 31.2 31.3	Introduction Seam Welded Pipe in the Creep Range Expansion Joints	31-1 31-1 31-2	33A.1 Introduction33A.2 The Fusion of Light Elements33A.3 Terrestrial-Scale Fusion	33-1 33-1 33-2
31.1 31.2 31.3 31.4	Introduction Seam Welded Pipe in the Creep Range Expansion Joints Water Hammer/Steam Hammer	31-1 31-1 31-2 31-3	 33A.1 Introduction 33A.2 The Fusion of Light Elements 33A.3 Terrestrial-Scale Fusion 33A.4 Terrestrial Power Production Theories 	33-1 33-1 33-2 33-4
31.1 31.2 31.3 31.4 31.5	Introduction Seam Welded Pipe in the Creep Range Expansion Joints Water Hammer/Steam Hammer Gas Blows	31-1 31-1 31-2 31-3 31-3	 33A.1 Introduction 33A.2 The Fusion of Light Elements 33A.3 Terrestrial-Scale Fusion 33A.4 Terrestrial Power Production Theories 33A.5 References 	33-1 33-1 33-2 33-4 33-4
31.1 31.2 31.3 31.4 31.5 31.6	Introduction Seam Welded Pipe in the Creep Range Expansion Joints Water Hammer/Steam Hammer Gas Blows Material Identification/Verification	31-1 31-1 31-2 31-3 31-3 31-4	 33A.1 Introduction 33A.2 The Fusion of Light Elements 33A.3 Terrestrial-Scale Fusion 33A.4 Terrestrial Power Production Theories 	33-1 33-1 33-2 33-4
31.1 31.2 31.3 31.4 31.5 31.6 31.7	Introduction Seam Welded Pipe in the Creep Range Expansion Joints Water Hammer/Steam Hammer Gas Blows	31-1 31-1 31-2 31-3 31-3	 33A.1 Introduction 33A.2 The Fusion of Light Elements 33A.3 Terrestrial-Scale Fusion 33A.4 Terrestrial Power Production Theories 33A.5 References 33A.6 Nomenclature 	33-1 33-1 33-2 33-4 33-4
31.1 31.2 31.3 31.4 31.5 31.6	Introduction Seam Welded Pipe in the Creep Range Expansion Joints Water Hammer/Steam Hammer Gas Blows Material Identification/Verification Flow Assisted Corrosion (FAC)	31-1 31-2 31-3 31-3 31-4 31-4 31-4 31-5	33A.1 Introduction 33A.2 The Fusion of Light Elements 33A.3 Terrestrial-Scale Fusion 33A.4 Terrestrial Power Production Theories 33A.5 References 33A.6 Nomenclature PART B: ITER	33-1 33-2 33-4 33-4 33-4
31.1 31.2 31.3 31.4 31.5 31.6 31.7 31.8	Introduction Seam Welded Pipe in the Creep Range Expansion Joints Water Hammer/Steam Hammer Gas Blows Material Identification/Verification Flow Assisted Corrosion (FAC) Vibration	31-1 31-1 31-2 31-3 31-3 31-4 31-4 31-4	33A.1 Introduction 33A.2 The Fusion of Light Elements 33A.3 Terrestrial-Scale Fusion 33A.4 Terrestrial Power Production Theories 33A.5 References 33A.6 Nomenclature PART B: ITER Brad Nelson.	33-1 33-1 33-2 33-4 33-4 33-4
31.1 31.2 31.3 31.4 31.5 31.6 31.7 31.8 31.9	Introduction Seam Welded Pipe in the Creep Range Expansion Joints Water Hammer/Steam Hammer Gas Blows Material Identification/Verification Flow Assisted Corrosion (FAC) Vibration Pipe Fittings	31-1 31-2 31-3 31-3 31-4 31-4 31-4 31-5	33A.1 Introduction 33A.2 The Fusion of Light Elements 33A.3 Terrestrial-Scale Fusion 33A.4 Terrestrial Power Production Theories 33A.5 References 33A.6 Nomenclature PART B: ITER Brad Nelson	33-1 33-1 33-2 33-4 33-4 33-5 33-5
31.1 31.2 31.3 31.4 31.5 31.6 31.7 31.8 31.9 31.10	Introduction Seam Welded Pipe in the Creep Range Expansion Joints Water Hammer/Steam Hammer Gas Blows Material Identification/Verification Flow Assisted Corrosion (FAC) Vibration Pipe Fittings Vacuum Conditions	31-1 31-2 31-3 31-3 31-4 31-4 31-4 31-5	33A.1 Introduction 33A.2 The Fusion of Light Elements 33A.3 Terrestrial-Scale Fusion 33A.4 Terrestrial Power Production Theories 33A.5 References 33A.6 Nomenclature PART B: ITER Brad Nelson	33-1 33-1 33-2 33-4 33-4 33-5 33-5
31.1 31.2 31.3 31.4 31.5 31.6 31.7 31.8 31.9 31.10	Introduction Seam Welded Pipe in the Creep Range Expansion Joints Water Hammer/Steam Hammer Gas Blows Material Identification/Verification Flow Assisted Corrosion (FAC) Vibration Pipe Fittings	31-1 31-2 31-3 31-3 31-4 31-4 31-4 31-5	33A.1 Introduction 33A.2 The Fusion of Light Elements 33A.3 Terrestrial-Scale Fusion 33A.4 Terrestrial Power Production Theories 33A.5 References 33A.6 Nomenclature PART B: ITER Brad Nelson	33-1 33-2 33-4 33-4 33-4 33-5 33-5 33-11
31.1 31.2 31.3 31.4 31.5 31.6 31.7 31.8 31.9 31.10 CHAP	Introduction Seam Welded Pipe in the Creep Range Expansion Joints Water Hammer/Steam Hammer Gas Blows Material Identification/Verification Flow Assisted Corrosion (FAC) Vibration Pipe Fittings Vacuum Conditions	31-1 31-2 31-3 31-3 31-4 31-4 31-5 31-5	33A.1 Introduction 33A.2 The Fusion of Light Elements 33A.3 Terrestrial-Scale Fusion 33A.4 Terrestrial Power Production Theories 33A.5 References 33A.6 Nomenclature PART B: ITER Brad Nelson	33-1 33-2 33-4 33-4 33-4
31.1 31.2 31.3 31.4 31.5 31.6 31.7 31.8 31.9 31.10 CHAP	Introduction Seam Welded Pipe in the Creep Range Expansion Joints Water Hammer/Steam Hammer Gas Blows Material Identification/Verification Flow Assisted Corrosion (FAC) Vibration Pipe Fittings Vacuum Conditions TER 32 TA: A SCALABLE APPROACH TO COMMER UCLEAR POWER: NUSCALE POWER'S NEW	31-1 31-2 31-3 31-3 31-4 31-4 31-5 31-5	33A.1 Introduction 33A.2 The Fusion of Light Elements 33A.3 Terrestrial-Scale Fusion 33A.4 Terrestrial Power Production Theories 33A.5 References 33A.6 Nomenclature PART B: ITER Brad Nelson. 33B.1 ITER Background 33B.2 ITER Design Description 33B.3 ITER Safety and Licensing 33B.4 References PART C: NUCLEAR FUSION	33-1 33-2 33-4 33-4 33-5 33-5 33-11 33-12
31.1 31.2 31.3 31.4 31.5 31.6 31.7 31.8 31.9 31.10 CHAPT	Introduction Seam Welded Pipe in the Creep Range Expansion Joints Water Hammer/Steam Hammer Gas Blows Material Identification/Verification Flow Assisted Corrosion (FAC) Vibration Pipe Fittings Vacuum Conditions FER 32 TA: A SCALABLE APPROACH TO COMMER UCLEAR POWER: NUSCALE POWER'S NEW PROACH TO SAFETY AND DEPLOYMENT OF	31-1 31-2 31-3 31-3 31-4 31-4 31-5 31-5	33A.1 Introduction 33A.2 The Fusion of Light Elements 33A.3 Terrestrial-Scale Fusion 33A.4 Terrestrial Power Production Theories 33A.5 References 33A.6 Nomenclature PART B: ITER Brad Nelson	33-1 33-2 33-4 33-4 33-5 33-5 33-11 33-12
31.1 31.2 31.3 31.4 31.5 31.6 31.7 31.8 31.9 31.10 CHAP	Introduction Seam Welded Pipe in the Creep Range Expansion Joints Water Hammer/Steam Hammer Gas Blows Material Identification/Verification Flow Assisted Corrosion (FAC) Vibration Pipe Fittings Vacuum Conditions FER 32 TA: A SCALABLE APPROACH TO COMMER UCLEAR POWER: NUSCALE POWER'S NEW PROACH TO SAFETY AND DEPLOYMENT ON NUCLEAR PLANTS J. Reyes and Daniel Ingersoll	31-1 31-2 31-3 31-3 31-4 31-4 31-5 31-5	33A.1 Introduction 33A.2 The Fusion of Light Elements 33A.3 Terrestrial-Scale Fusion 33A.4 Terrestrial Power Production Theories 33A.5 References 33A.6 Nomenclature PART B: ITER Brad Nelson	33-1 33-2 33-4 33-4 33-4 33-5 33-5 33-11 33-12
31.1 31.2 31.3 31.4 31.5 31.6 31.7 31.8 31.9 31.10 CHAPT NAF	Introduction Seam Welded Pipe in the Creep Range Expansion Joints Water Hammer/Steam Hammer Gas Blows Material Identification/Verification Flow Assisted Corrosion (FAC) Vibration Pipe Fittings Vacuum Conditions FER 32 TA: A SCALABLE APPROACH TO COMMER UCLEAR POWER: NUSCALE POWER'S NEW PROACH TO SAFETY AND DEPLOYMENT ON NUCLEAR PLANTS J. Reyes and Daniel Ingersoll.	31-1 31-2 31-3 31-3 31-4 31-4 31-5 31-5	33A.1 Introduction 33A.2 The Fusion of Light Elements 33A.3 Terrestrial-Scale Fusion 33A.4 Terrestrial Power Production Theories 33A.5 References 33A.6 Nomenclature PART B: ITER Brad Nelson. 33B.1 ITER Background 33B.2 ITER Design Description 33B.3 ITER Safety and Licensing 33B.4 References PART C: NUCLEAR FUSION Irving Zatz	33-1 33-2 33-4 33-4 33-5 33-5 33-11 33-12
31.1 31.2 31.3 31.4 31.5 31.6 31.7 31.8 31.9 31.10 CHAP	Introduction Seam Welded Pipe in the Creep Range Expansion Joints Water Hammer/Steam Hammer Gas Blows Material Identification/Verification Flow Assisted Corrosion (FAC) Vibration Pipe Fittings Vacuum Conditions FER 32 TA: A SCALABLE APPROACH TO COMMER UCLEAR POWER: NUSCALE POWER'S NEW PROACH TO SAFETY AND DEPLOYMENT ON NUCLEAR PLANTS J. Reyes and Daniel Ingersoll	31-1 31-2 31-3 31-3 31-4 31-4 31-5 31-5	33A.1 Introduction 33A.2 The Fusion of Light Elements 33A.3 Terrestrial-Scale Fusion 33A.4 Terrestrial Power Production Theories 33A.5 References 33A.6 Nomenclature PART B: ITER Brad Nelson	33-1 33-2 33-4 33-4 33-5 33-5 33-11 33-12
31.1 31.2 31.3 31.4 31.5 31.6 31.7 31.8 31.9 31.10 CHAPT NAF NAF José N 32A 32A.1	Introduction Seam Welded Pipe in the Creep Range Expansion Joints Water Hammer/Steam Hammer Gas Blows Material Identification/Verification Flow Assisted Corrosion (FAC) Vibration Pipe Fittings Vacuum Conditions FER 32 TA: A SCALABLE APPROACH TO COMMER UCLEAR POWER: NUSCALE POWER'S NEW PROACH TO SAFETY AND DEPLOYMENT ON NUCLEAR PLANTS J. Reyes and Daniel Ingersoll	31-1 31-2 31-3 31-3 31-4 31-4 31-5 31-5 31-5	33A.1 Introduction 33A.2 The Fusion of Light Elements 33A.3 Terrestrial-Scale Fusion 33A.4 Terrestrial Power Production Theories 33A.5 References 33A.6 Nomenclature PART B: ITER Brad Nelson. 33B.1 ITER Background 33B.2 ITER Design Description 33B.3 ITER Safety and Licensing 33B.4 References PART C: NUCLEAR FUSION Irving Zatz 33C.1 Introduction 33C.2 Nuclear Fusion in the US 33C.3 Fusion Energy Sciences (FES)	33-1 33-2 33-4 33-4 33-4 33-5 33-5 33-12 . 33-13 33-13 33-13
31.1 31.2 31.3 31.4 31.5 31.6 31.7 31.8 31.9 31.10 CHAPT NAF NAF NAF NAF NAF NAF NAF NAF NAF NAF	Introduction Seam Welded Pipe in the Creep Range Expansion Joints Water Hammer/Steam Hammer Gas Blows Material Identification/Verification Flow Assisted Corrosion (FAC) Vibration Pipe Fittings Vacuum Conditions FER 32 TA: A SCALABLE APPROACH TO COMMER UCLEAR POWER: NUSCALE POWER'S NEW PROACH TO SAFETY AND DEPLOYMENT ON NUCLEAR PLANTS J. Reyes and Daniel Ingersoll	31-1 31-2 31-3 31-3 31-4 31-4 31-5 31-5 31-5	33A.1 Introduction 33A.2 The Fusion of Light Elements 33A.3 Terrestrial-Scale Fusion 33A.4 Terrestrial Power Production Theories 33A.5 References 33A.6 Nomenclature PART B: ITER Brad Nelson. 33B.1 ITER Background 33B.2 ITER Design Description 33B.3 ITER Safety and Licensing 33B.4 References PART C: NUCLEAR FUSION Irving Zatz 33C.1 Introduction 33C.2 Nuclear Fusion in the US 33C.3 Fusion Energy Sciences (FES) 33C.4 ASME Standards	33-1 33-2 33-4 33-4 33-5 33-5 33-11 33-12 . 33-13 33-13 33-14 33-14